Fusion Theory and Computing

Number Crunching

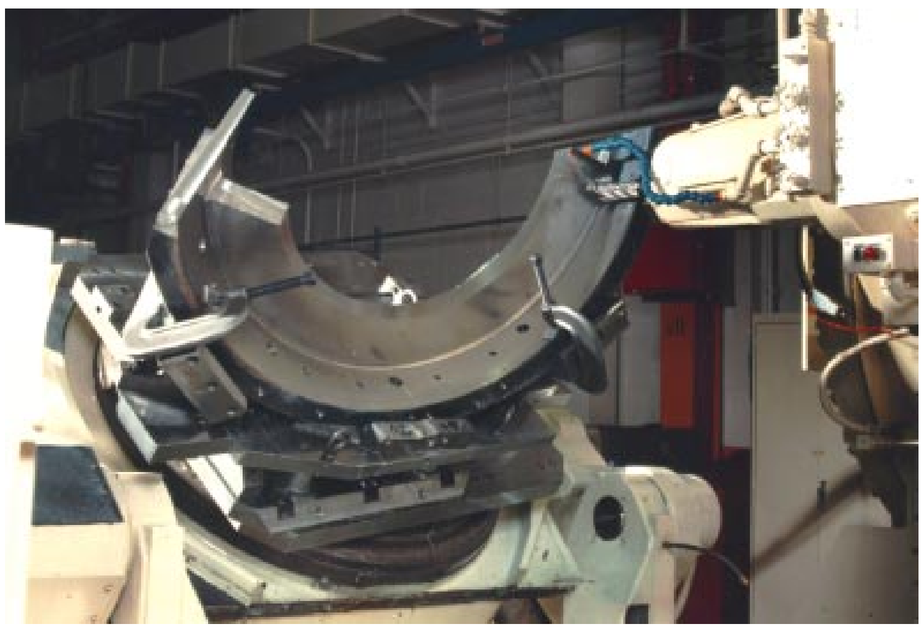
The behavior of a fusion plasma is extremely complicated. A plasma can exert pressure against the confining magnetic field, carry currents, oscillate, radiate energy, undergo particle loss, or become unstable. Understanding this behavior is the province of fusion theorists, who explore the physics of plasmas and also develop and use computational tools for analysis and modeling and for optimizing the configurations of fusion devices.

In their quest for powerful computing technology and computational techniques, fusion researchers have both helped to develop and benefited from advances in supercomputers, parallel processing, and high-speed computer networks. Computer codes, numerical techniques, and engineering applications developed for fusion are being used to examine a wide variety of problems, including precision construction, the national air traffic control system, and global warming. Visualization techniques are being applied to every field that relies on computer calculations and data analysis.

The National Research and Education Network, mandated by the High Performance Computing and Communications Act of 1991, has its roots in the national computer network originally developed to support centralized supercomputing for fusion research. As part of this initiative, the fusion program has been instrumental in establishing links between the big science at national laboratories and the teachers and students of high school and college science and mathematics.

Models of plasma behavior have produced new understanding of phenomena outside fusion. For example, the ability to model the dynamics of turbulent flows, which is critical to controlling a fusion plasma, is also a key to the prediction of global climate changes. These problems are being addressed with the new supercomputers and massively parallel computers. Work to help users interpret the meaning of the vast amounts of data available from these computers has produced visualization hardware and software.

Fusion researchers have assisted the Federal Aviation Administration in developing methods for analysis and real-time modeling of the national air traffic control system. The ability to analyze system loading and its anomalies will improve the ability to deal with changing traffic loads, weather-related delays, or other problems.



Fusion experimental devices require precision measurement and engineering techniques to ensure that they will operate as planned. Computational methods have been developed to support these requirements and applied to the characterization, measurement, and positioning of components for other complicated systems.

A virtual reference technique was developed at Oak Ridge National Laboratory to allow machining of complicated castings with no reference surfaces on a five-axis, numerically controlled milling machine, shown above. Virtual reference points, calculated and represented by tooling balls, are used to define a casting's position. The milling machine is then programmed with these definitions so that the casting can be machined without being repositioned. These techniques have been used to measure castings for the armed forces and are available for industrial applications.